Cover Crops and Crop Residue in the Nitrogen Budget

Monday October 26, 2020

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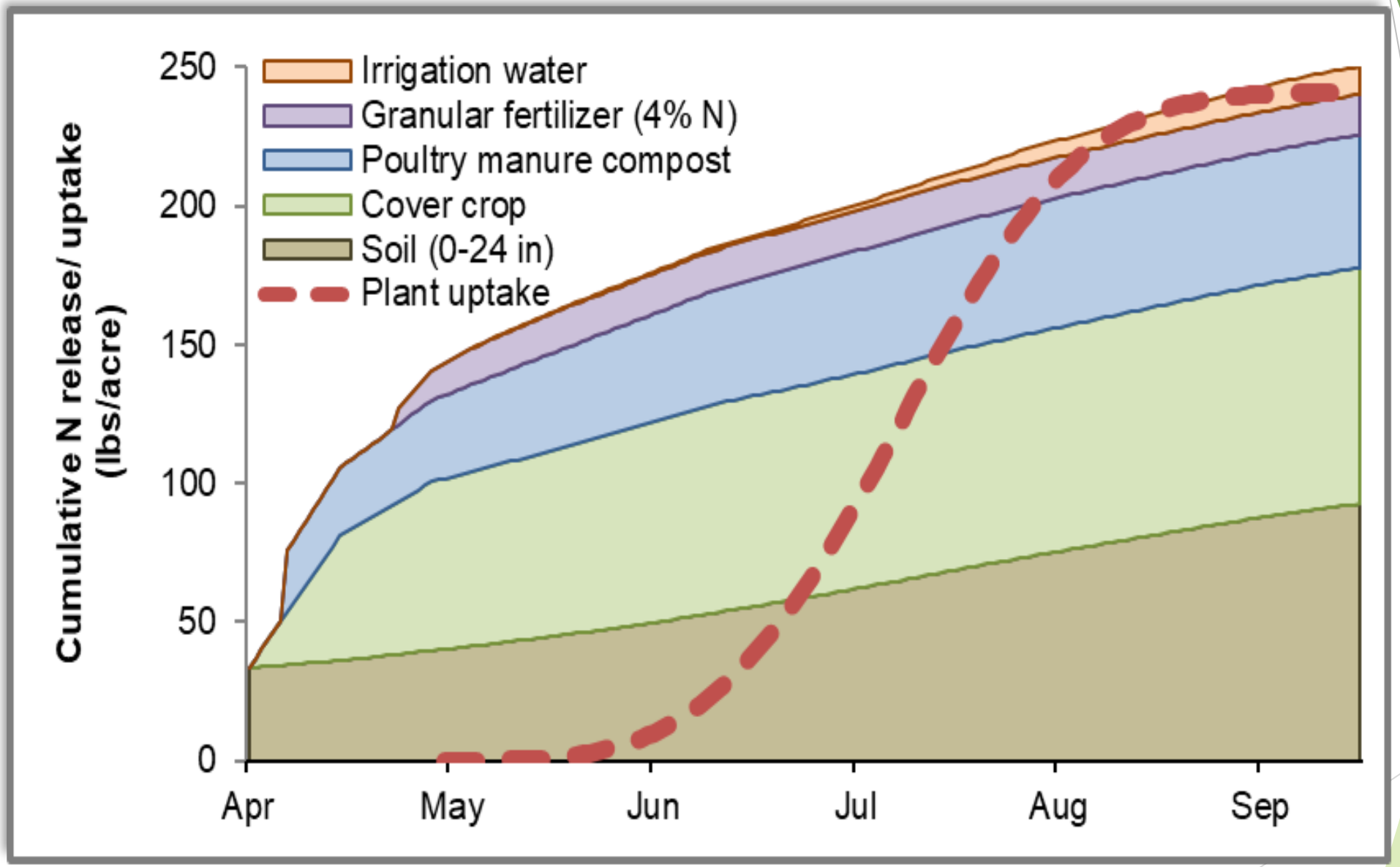
UCCE Small Farms Advisor

Yolo Solano and Sacramento Counties


Cumulative N release/ uptake (lbs/acre)
250
200
150
100
50
0
Irrigation water
Granular fertilizer (4% N)
Poultry manure compost
Cover crop
Soil (0-24 in)
Plant uptake
Apr
May
Jun
Jul
Aug
Sep

The amount of N made available from crop residues depends on:

- Biomass of the residues
- N content of the residues
- C:N ratio
- Soil moisture
- Whether residues are left on the surface or incorporated

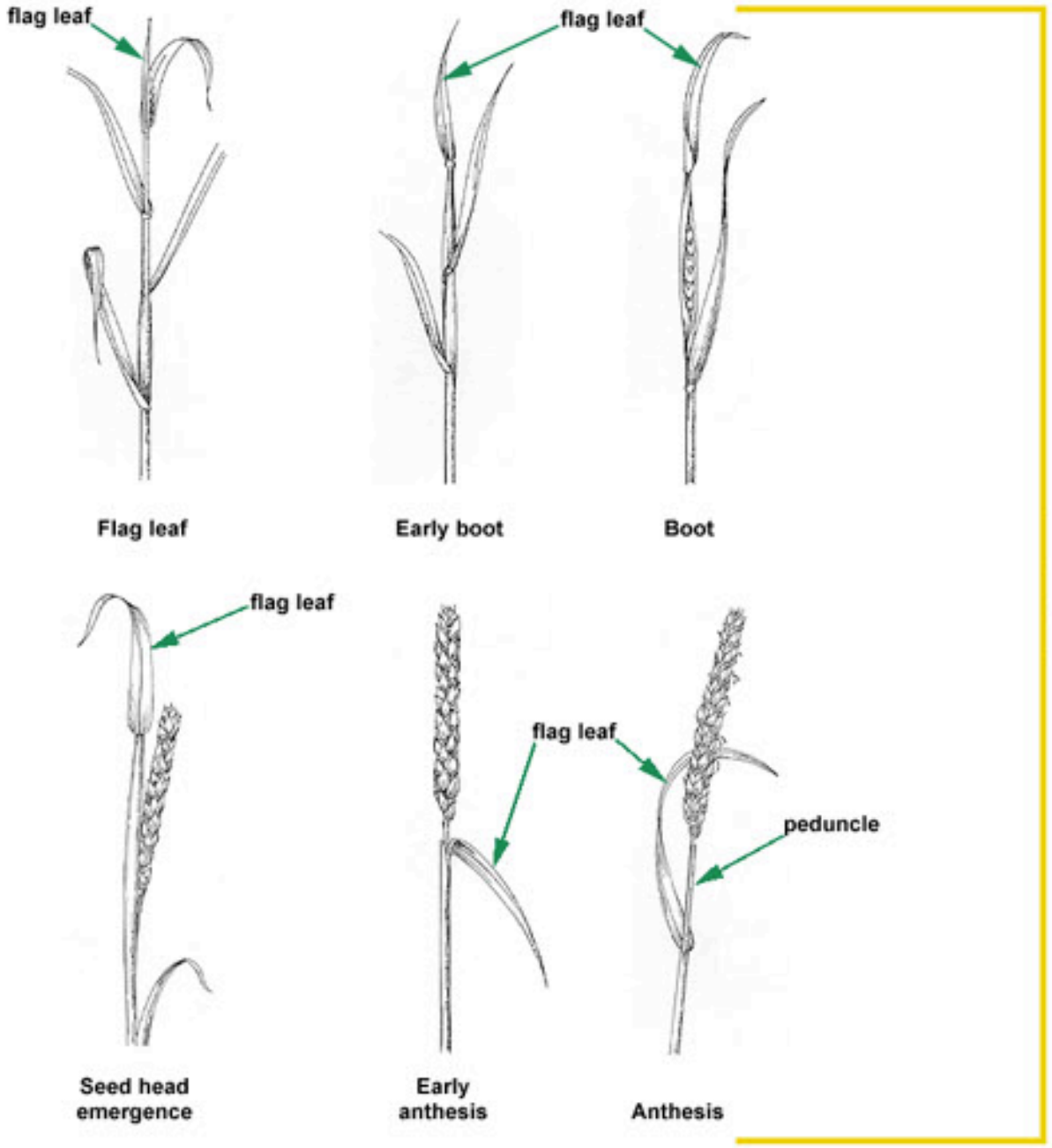
Quantity Quality Availability

Biomass of the residues

- **The vast majority of N in cover crop biomass is found in the above-ground plant biomass**


5


5
4
3
2



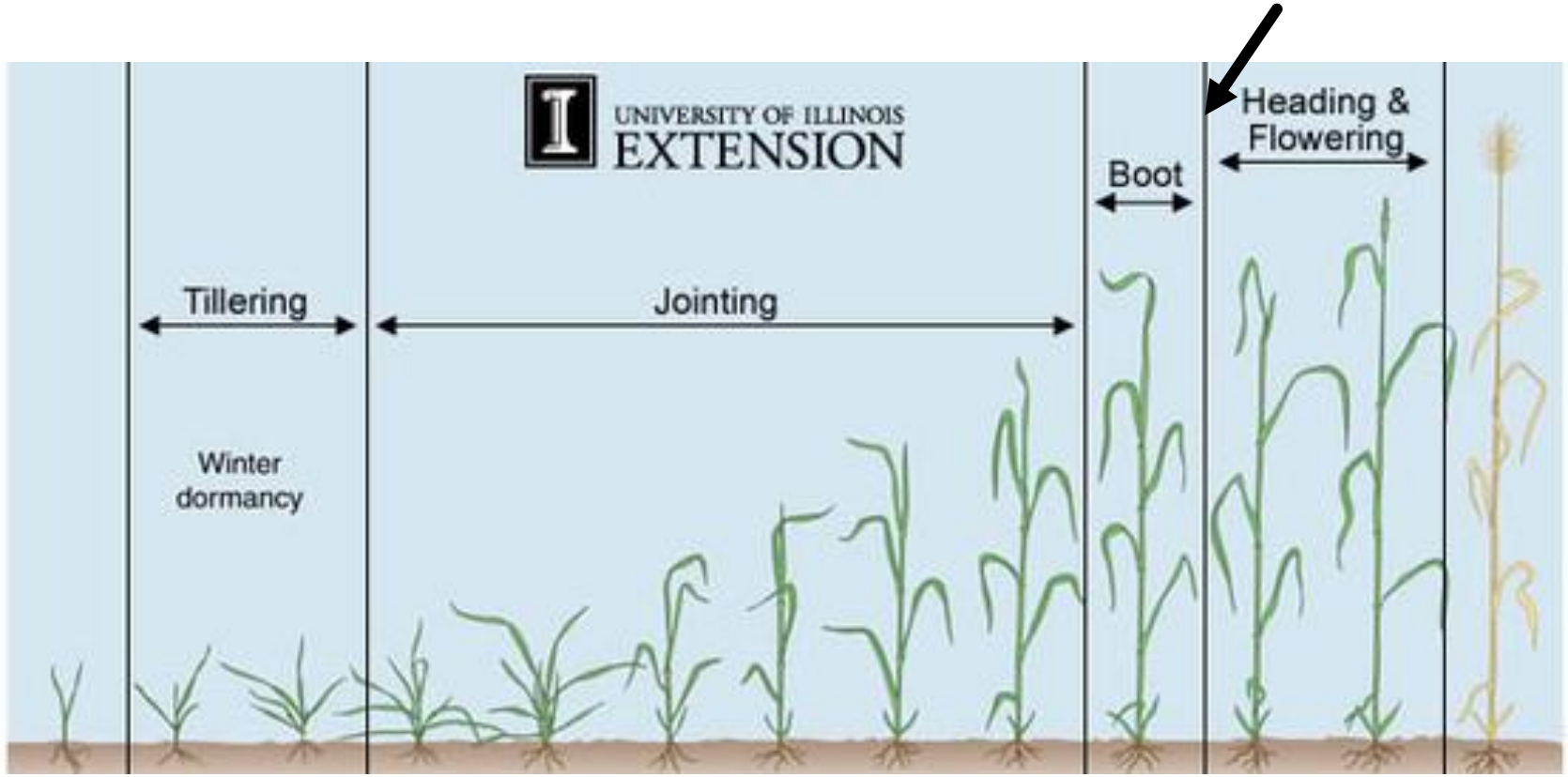
Grass growth

Reproductive phase

Feek
Zado

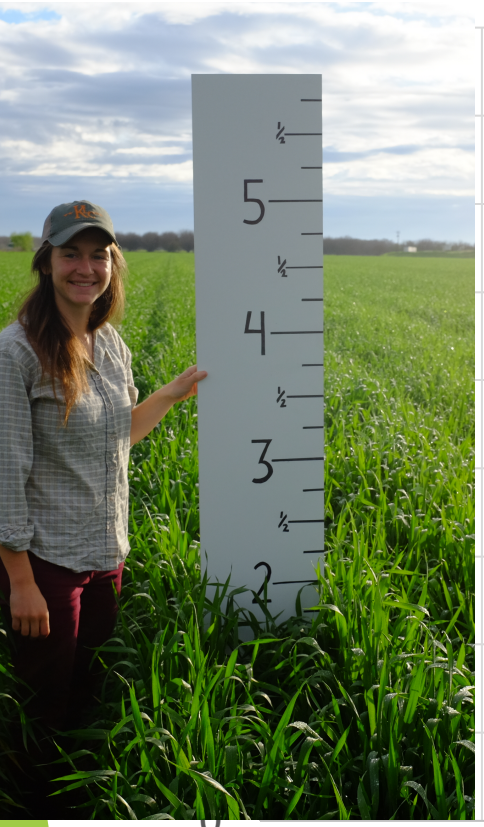
; Clark et al., 1994; Vaughan and Evanylo, 1998).

- After the boot growth stage, rye cover crops can double in biomass with little additional N



(Dabney et al. 2001, Shipley et al., 1992; Clark et al., 1994; Vaughan and Evanylo, 1998).

Biomass accumulation in wheat (Yolo Co., 2017)



Unpublished data, courtesy of Mark Lundy, UCCE Extension Specialist, Small Grains

Biomass of the residues

- **The vast majority of N in cover crop biomass is found in the above-ground plant biomass**

…regardless of whether the N came from residual nitrate in the soil or atmospheric N fixed by bacteria in legume roots.

Roots from cover crop of hairy vetch and Austrian pea:
10 lb N/A
<2% N
C:N ratio >20:1
PAN release close to 0

(Kuo et al., 1997)

Table 4 (p. 17)

Cover Crop	Crop Biomass (dry) (T/A)	Tissue N Content (%)	Total N in Crop Biomass (lb/A)	Estimated N availability for next crop at 4-45% release (lb/A)
'Cayuse' Oats	4	1.7	136	5-61
'Merced' Rye	3.6	1.9	137	5-62
Mustard[1]	3	2.6	156	6-70
Bell Bean	3	2.7	162	6-73
Cereal/Legume Mix[2]	3	2.9	174	7-78
'Magnus' Pea	2	3.6	144	6-65
Purple Vetch	2	3.7	148	6-67
'Lana' Woollypod Vetch	2	4.7	188	8-85

April 2019 Cover Crop Sampling Results

Field[a]	Cover Crop[b]	Planting Date	Seeding Rate (lb/A)	Biomass (lb/A, dry)
1	Wheat			5562
2	Common Vetch	11/15/18	60	4786
3	Common Vetch	11/15/18	100	4221
4	Mix 1 (legume only)	11/15/18	100	4550
5	Mix 2 (legume + oats)	10/20/18	100	5628
6	Mix 3 (legume + oats)	11/1/18	118	5872

Table 21. Hairy vetch cultivar average dry matter percent, total percent nitrogen, estimated dry matter yield and total nitrogen yield collected at the Lockeford Plant Materials Center, CA 2016/17 and 2017/18.

Cultivar	2016/17 DM	2016/17 Total N	2016/17 Estimated DM Yield	2016/17 Estimated Total N Yield	2017/18 DM	2017/18 Total N	2017/18 Estimated DM Yield	2017/18 Estimated Total N Yield
	——%——		—lb/ac—	—lb/ac—	——%——		—lb/ac—	—lb/ac—
CCS-Groff	22.6	3.0	7,038	208	19.4	3.4	9,165	309
Lana	17.4	4.3	7,118	305	17.7	3.7	7,533	275
Purple Bounty	17.0	3.3	5,513	182	20.3	3.6	8,772	318
Purple Prosperity	21.4	2.8	7,975	222	19.0	2.8	11,666	330
TNT	18.0	3.6	7,567	269	20.3	3.6	10,536	381
Villana	19.6	3.0	6,598	198	19.4	3.6	10,238	373
Mean	19.3	3.3	6,901	231	19.4	3.5	9,756	335
Std. dev[#]	2.3	0.6	773	47	1.0	0.3	1,444	39

[#]Standard deviation

DM and N were measurements of composite samples collected at 50% bloom.

Est. DM Calculation: Fresh Weight Aboveground Biomass x (DM/100)

Est. Total N Yield Calculation: (Total N/100) x DM Yield

DM = dry matter, N = nitrogen, lb/ac = pounds/acre.

N content of the residues

- **Generally, cover crop age and N content drive N availability**
  - **the younger the crop and higher the N content of that species, the higher the N availability following incorporation.**
- Legumes and mustards have higher N contents in their tissue (e.g. >2%) that allows for more rapid N mineralization.
- The N content of cereals can be >2% when they are juvenile (e.g. prior to flowering), but significantly declines as they mature. As a result, the amount of N that is mineralized from cereal cover crop biomass can be less than legumes.

Cover Crop	Crop Biomass (dry) (T/A)	Tissue N Content (%)	Total N in Crop Biomass (lb/A)	Estimated N availability for next crop at 4-45% release (lb/A)
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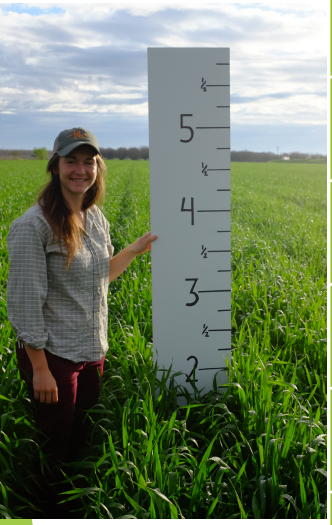
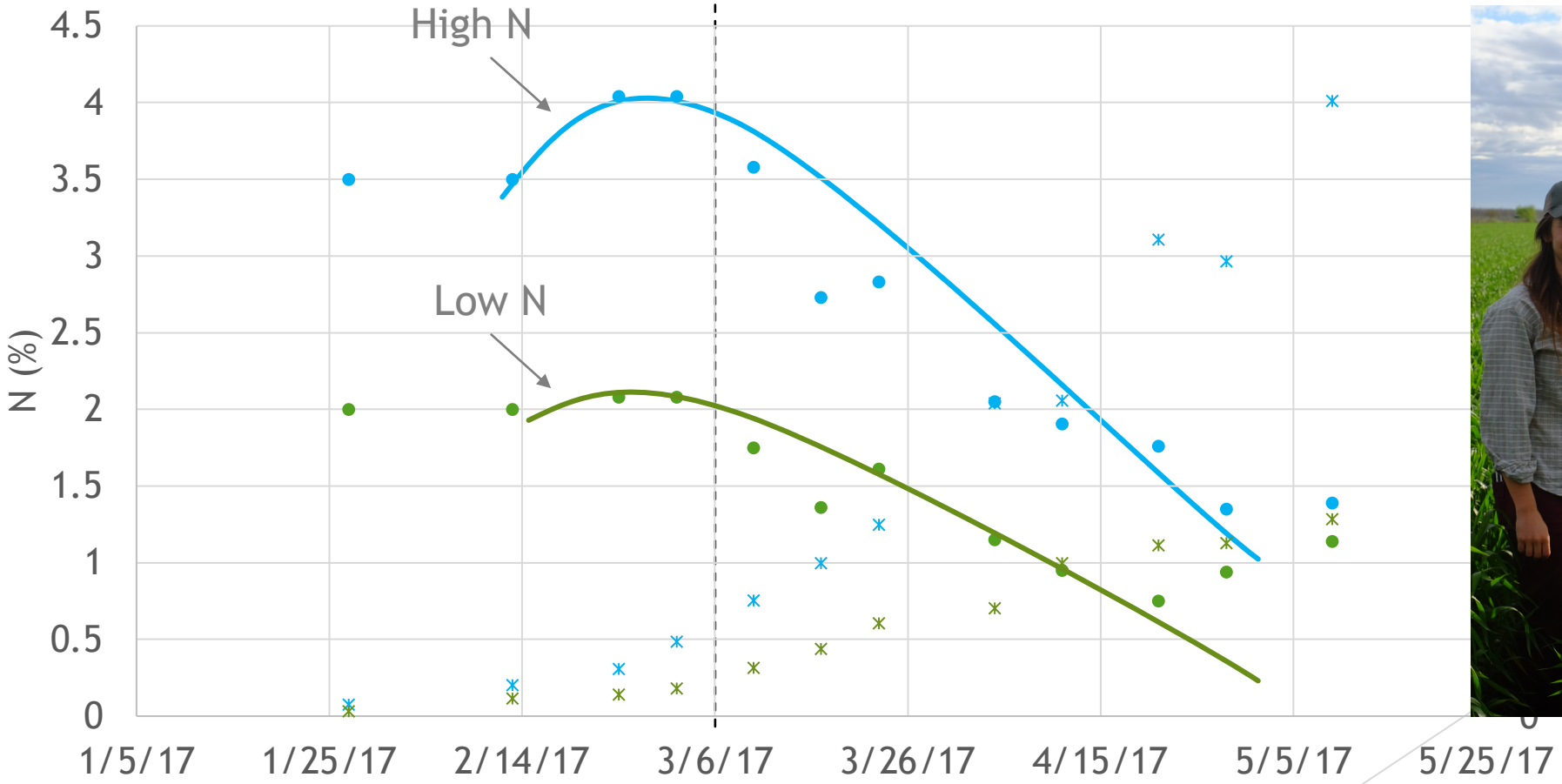
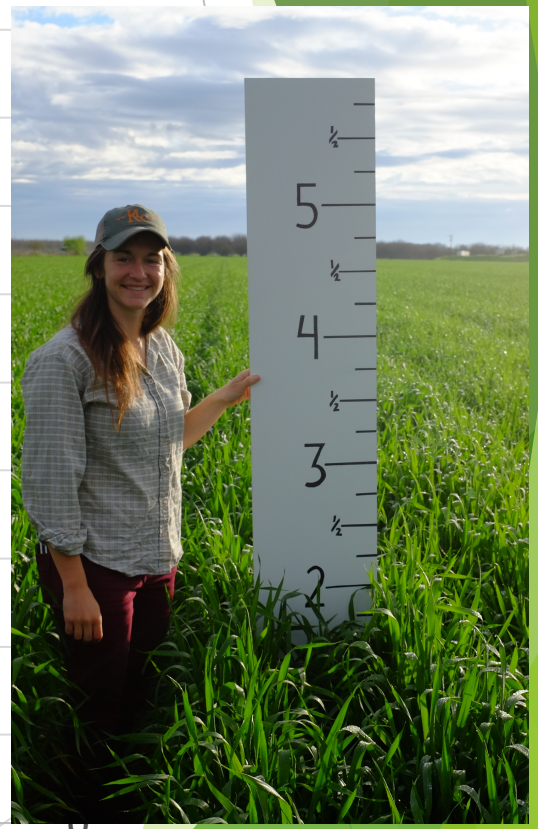


Cover Crop	Planting Date	Total N (%)	C:N
Wheat		2.7	18:1
Common Vetch	11/15/18	3.5	15:1
Common Vetch	11/15/18	3.9	12:1
Mix 1 (legume only)	11/15/18	4.1	12:1
Mix 2 (legume + oats)	10/20/18	2.9	18:1
Mix 3 (legume + oats)	11/1/18	3	17:1

Yolo/Solano Cos, Sampled April 1-15, 2019

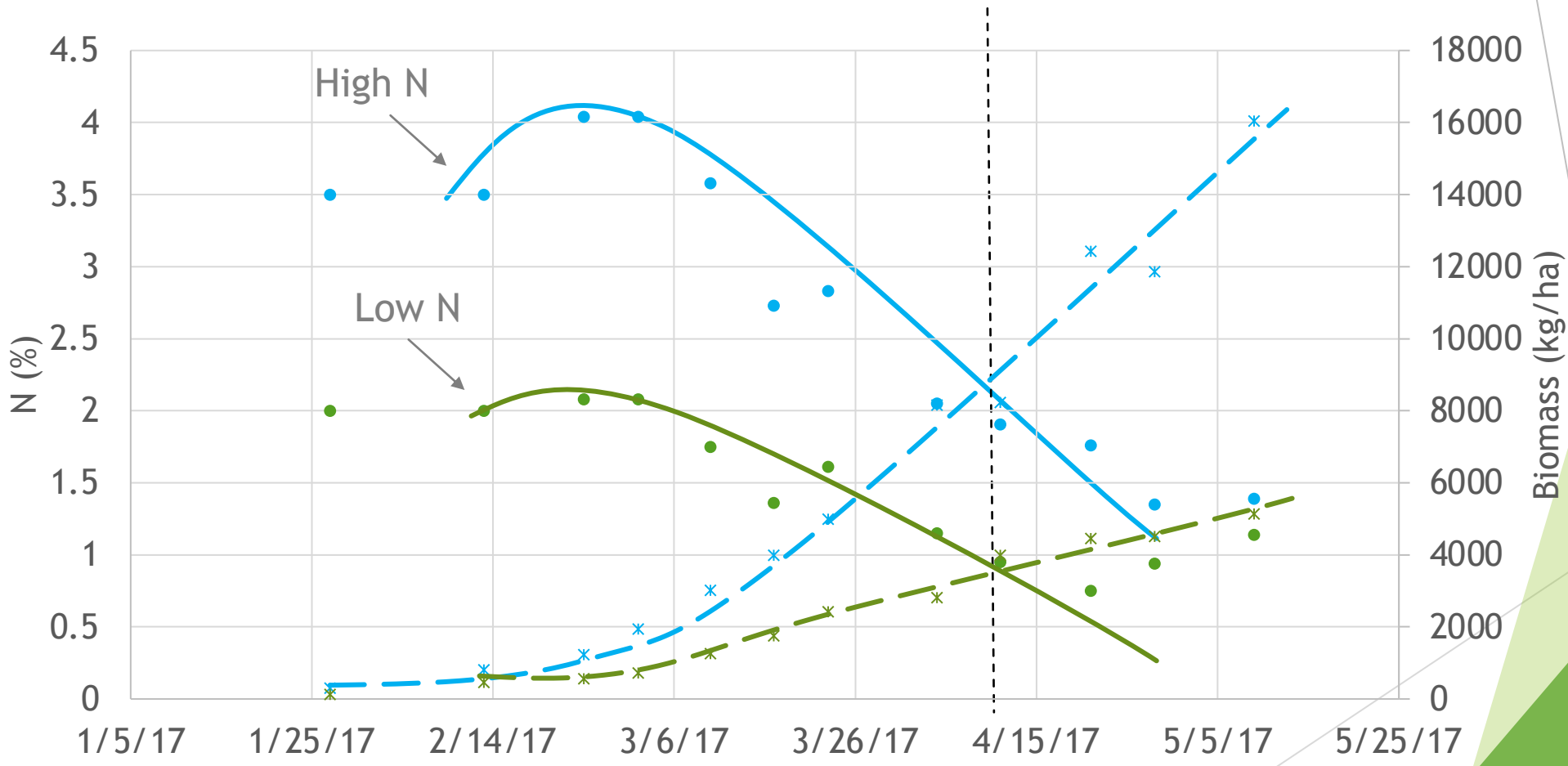
- For most crops, peak total N content occurs just before/at flower, when biomass is high and N remains in the tissue prior to use for seed production





Unpublished data, courtesy of Mark Lundy, UCCE Extension Specialist, Small Grains

Relationship between %N in leaf tissue and biomass accumulation in wheat (Yolo Co., 2017)



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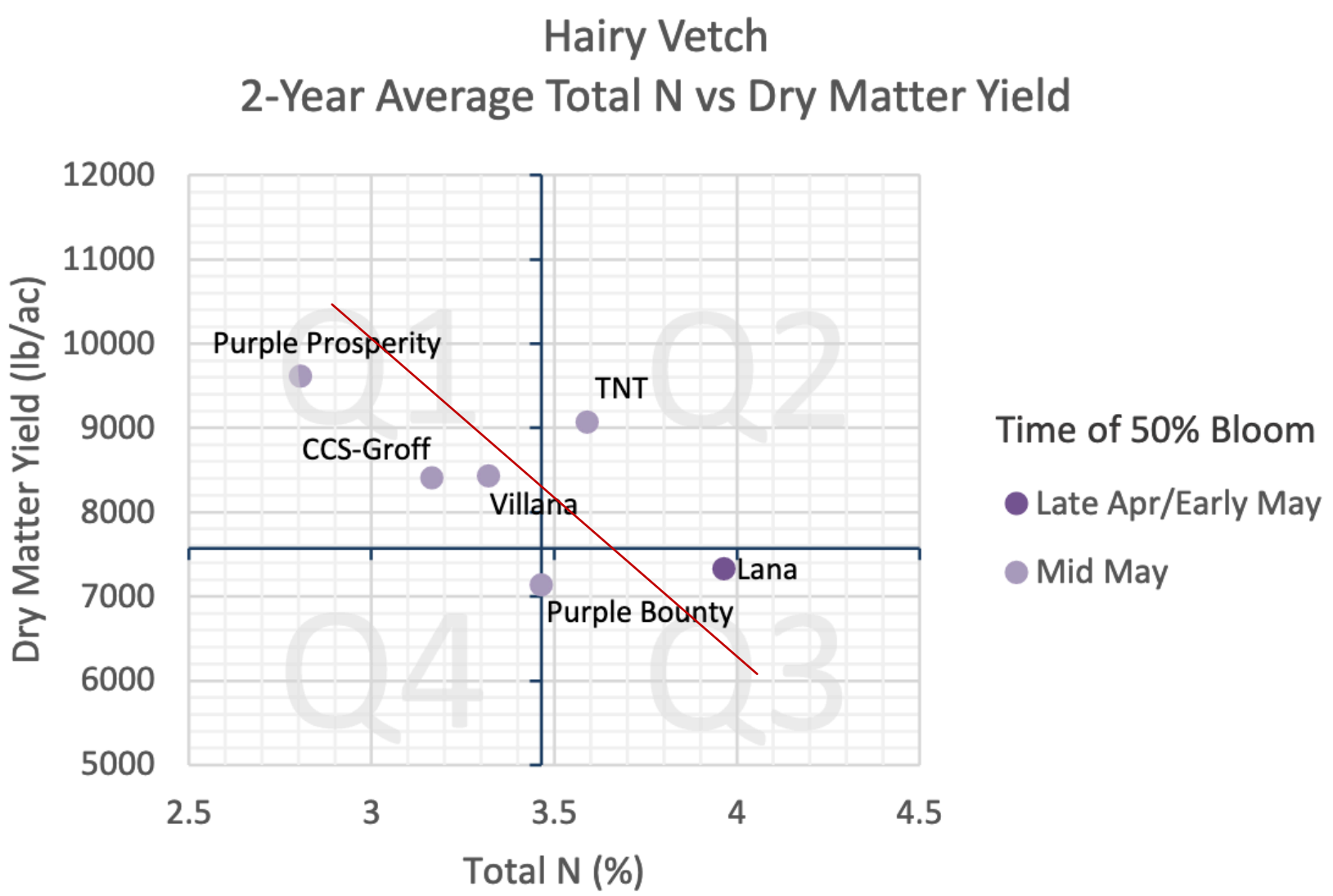

Hairy Vetch
2-Year Average Total N vs Dry Matter Yield
Dry Matter Yield (lb/ac)
12000
11000
10000
9000
8000
7000
6000
5000
2.5
3
3.5
4
4.5
Total N (%)
Q1
Q2
Q3
Q4
Purple Prosperity
TNT
CCS-Groff
Villana
Lana
Purple Bounty
Time of 50% Bloom
Late Apr/Early May
Mid May

Legumes

- This ability to extract atmospheric N means they provide a net input of N to the soil when incorporated
- Typically have higher N content in their tissues.
- Usually accumulate N longer in the spring than non-legume cover crop

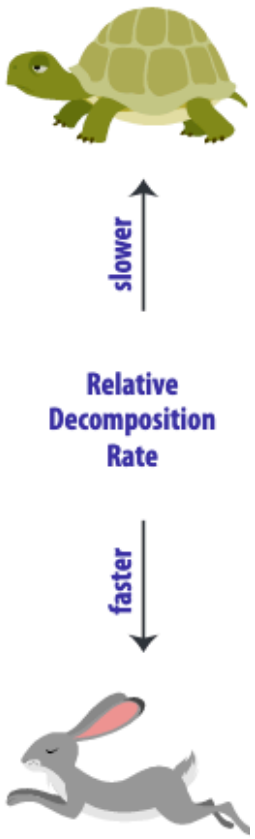
Legume-Cereal Cover Crop Mixes

- Growing grass /legume mixtures typically increases total carbon inputs without sacrificing N scavenging efficiency and N contributions
- Cover crop mixes with a higher proportion of legumes, particularly when terminated before flowering will release more of their N than later terminated cover crops and grass-heavy mixes.

C:N ratio
(Carbon to nitrogen ratio)

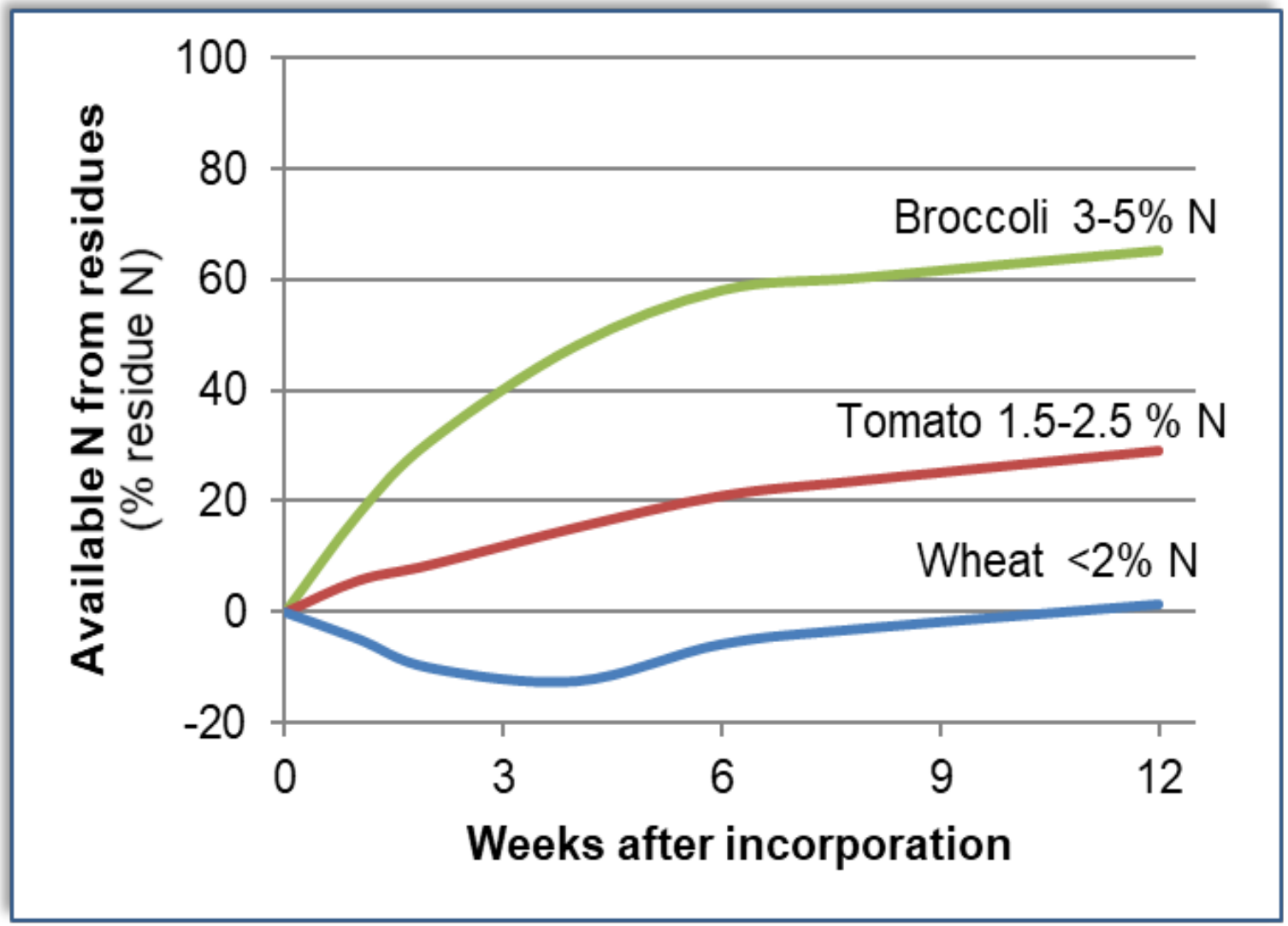
Table 1. Carbon to nitrogen ratios of crop residues and other organic materials

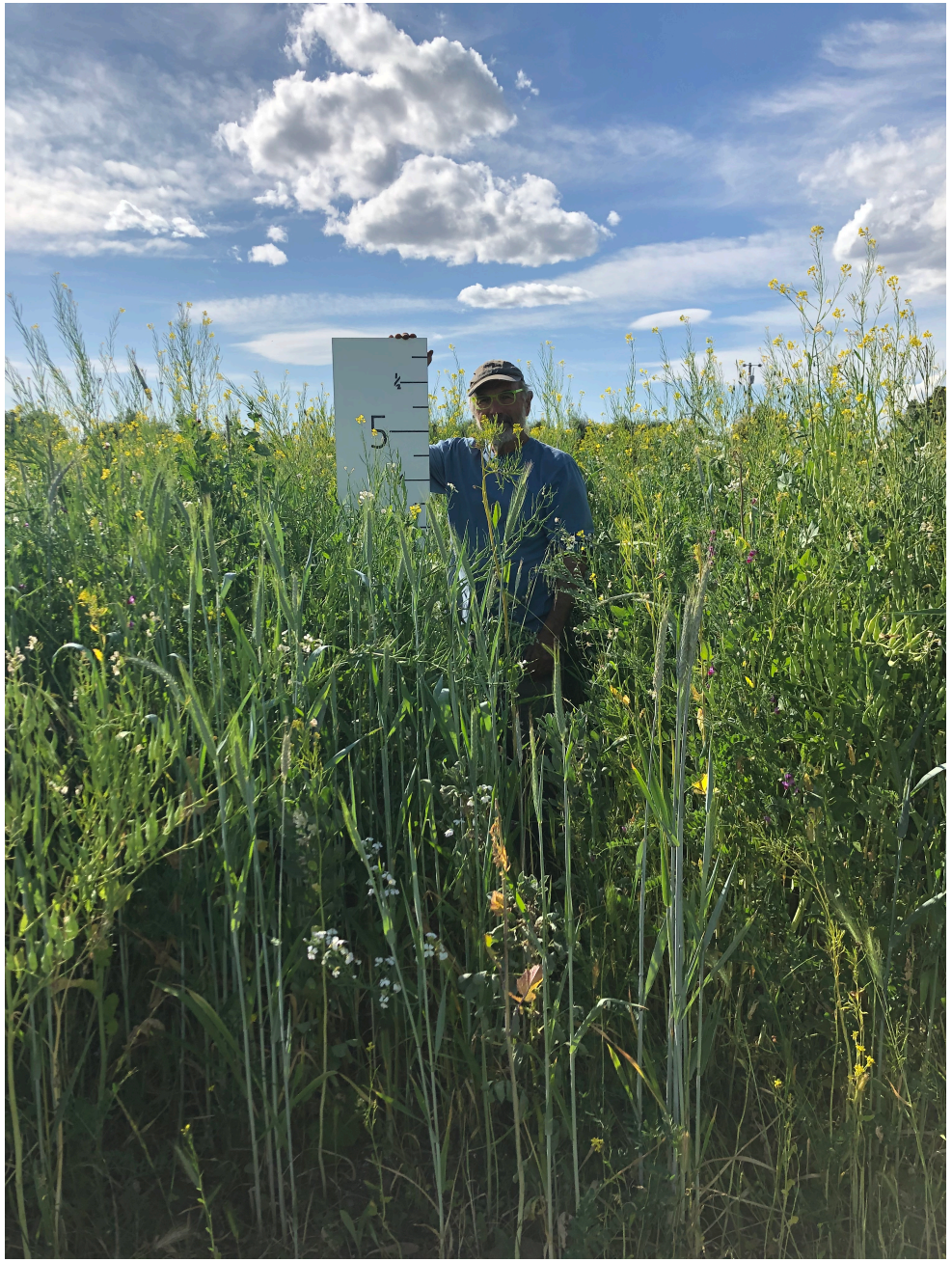
Material	C:N Ratio
rye straw	82:1
wheat straw	80:1
oat straw	70:1
corn stover	57:1
rye cover crop (anthesis)	37:1
pea straw	29:1
rye cover crop (vegetative)	26:1
mature alfalfa hay	25:1
Ideal Microbial Diet	**24:1**
rotted barnyard manure	20:1
legume hay	17:1
beef manure	17:1
young alfalfa hay	13:1
hairy vetch cover crop	11:1
soil microbes (average)	8:1



- Lignin, carbohydrates, and cellulose content can affect the rate of N release from the cover crop residues
- **The lower the C:N ratio, the faster mineralization and the more N becomes available for plant uptake.**
- Ex. An early spring kill of cereal grains reduces accumulation of C more than of N, so the rate of release of cover crop N into following crops is faster

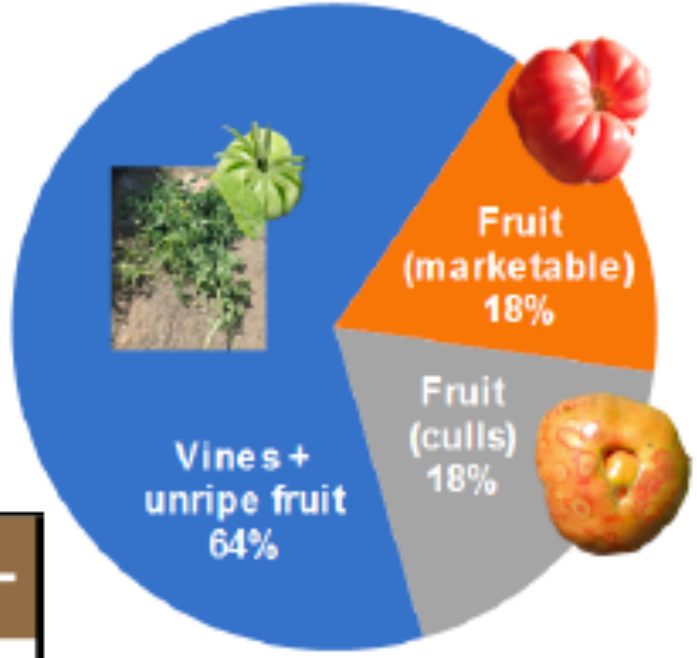
Table 1 from NRCS


Available N from residues
(% residue N)
100
80
60
40
20
0
-20
0
3
6
9
12
Weeks after incorporation
Broccoli 3-5% N
Tomato 1.5-2.5 % N
Wheat <2% N



April 22, 2020
C:N 32:1

Vegetable Crop Residue



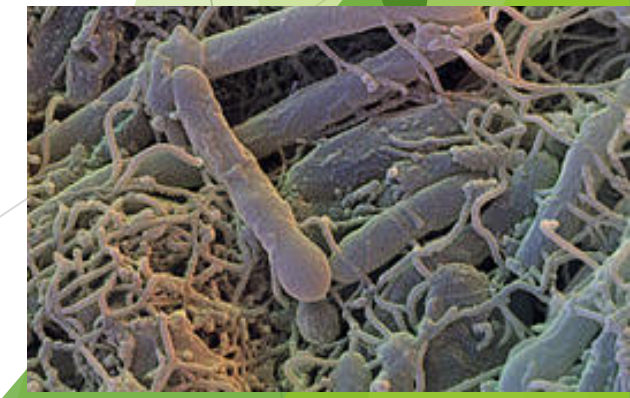
Crop	Example yield (tons/acre)	N in residues (% of total)	Expected residue N (lb N/ton yield)	Expected residue N (lb N/acre)
Lettuce	20	68	5	100
Tomato (fresh-market)	30	56	4	130
Tomato (processing)	50	46	2	100
Broccoli	10	68	24	240
Carrot	20	67	7	140
Melon	20	40	3	60
Potato	25	44	5	125
Strawberry	40	46	2	80
Spinach	15	38	3	45

Soil moisture

- Microbes and organisms decomposing plant residue need moisture
- Shoot material contains moisture—often lots, easily 50% moisture by weight.

Whether residues are left on the surface or incorporated.

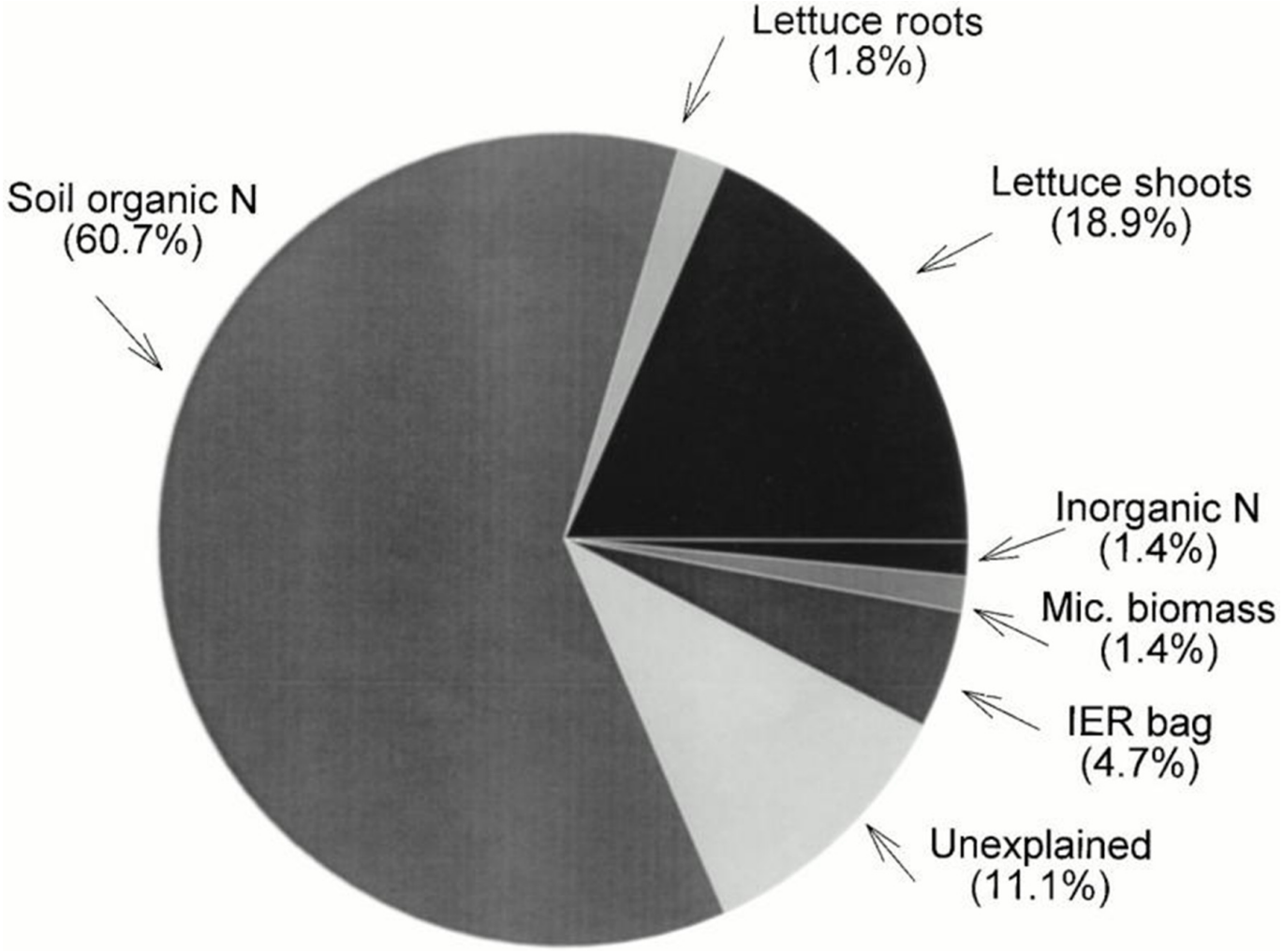
- **Surface-applied residues decay more slowly than incorporated residues,**
  - …since residue decomposition is a microbial process requiring contact with microbes and moisture.
  - surface-applied residues are more vulnerable to N loss via volatilization to the atmosphere.
- The slower N release from cover crop residues left on the soil surface is more pronounced in dry than in wet years, is most evident during the first 4 to 8 weeks after killing, and differences due to tillage in accumulative N release disappear after 16 weeks (Varco et al., 1989)



The amount of cover crop N that is made available for vegetable crop growth varies widely, and estimates range from 4-35%.

- Unmineralized N from cover crops contributes to the total N in the soil organic matter and long-term soil fertility.

Proportion of cover crop residue that was recovered in plant and soil components at harvest of the first lettuce crop at 4 months post incorporation



Jackson, L.E. (2000), Fates and Losses of Nitrogen from a Nitrogen-15-Labeled Cover Crop in an Intensively Managed Vegetable System. Soil Sci. Soc. Am. J., 64: 1404-1412.

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Example Scenario Summary

- Cover crop mixes with a higher proportion of legumes, particularly when terminated before flowering will release more of their N than later terminated cover crops and grass-heavy mixes.
- An early spring kill of cereal grains reduces accumulation of C more than of N, so the rate of release of cover crop N into following crops is faster
- In a cover crop mix, low residual soil N will limit cereal growth and promote legume growth
- A wet winter will encourage more rapid cover crop decomposition, which will lead to sooner availability and higher availability of early nitrogen

Summary

The amount of cover crop/crop residue N that is made available for vegetable crop growth varies widely, and estimates vary from 4-35, 4-45%.

- **C:N ratio and %N strongly influence plant-available N (PAN)**
  - **the younger the crop and higher the N content of that species, the higher the N availability following incorporation**
  - **Legumes and mustards tend to have higher %N tissue than cereals**
- More biomass leads to more total N contribution (no necessarily PAN)
  - The age of that biomass influences PAN
- Soil moisture determines when/how much decomposition occurs
- Residue incorporation vs surface mulch determines when/how much decomposition occurs

Cover Crop Chart

----------Cool Season---------- ----------Warm Season----------

---Grass---

---Grass---

----------Broadleaf----------

----------Legume----------

								Corn
	Brassicas	Fava bean						Japanese millet
	Flax	Field pea	Balansa clover	Red clover	Common vetch	Chickpea	Amaranth	Proso millet
	Phacelia	Lentil	Berseem clover	Rose clover	Hairy vetch	Cowpea	Buckwheat	Sorghum
	Radish	Lupine	Crimson clover	Sweetclover	Purple vetch	Soybean	Safflower	Sudangrass
	White mustard	Medic/burr clover	Persian clover	Subterranean clover	Woollypod vetch	Sunnhemp	Sunflower	Teff

Woollypod Vetch (*Vicia villosa* Roth. subsp. *varia*)

- Cool season broadleaf, annual legume
- Height: 18 -27 inches tall, but will climb
- Fair drought tolerance
- Typically planted: Early to mid-Fall, most growth in spring.
- Seeding rate: 25 lb/acre
- Seeding depth: 0.75 inches
- Biomass: 8,000 lb/acre
- 'Lana' vetch can contribute 100 -300 lb N/acre
- Maturity: Early
- Termination strategies:
  - Low cut at full bloom,
  - Tillage
  - Herbicide
- Purpose: Nitrogen fixation, increase organics, reduce soil compaction, suppress weeds and will overgrow and smother other plants.
- Flowers attract pollinators, especially attractive to European honey bees.

UC SARAP Cover Crop database
https://plants.usda.gov/plantguide/pdf/pg_viviv8.pdf
'Lana' Woollypod Vetch Release Brochure

Woollypod vetch (Lana), Lockeford PMC.

Pest Alert:

- Insects: Can attract Western tarnished plant bug and twospotted spider mite.
- Disease: Potential host for *Sclerotinia minor*.
- Weediness: Most harded seeded vetch and will persist in California's Central Valley. Some populations tolerant to glyphosate.

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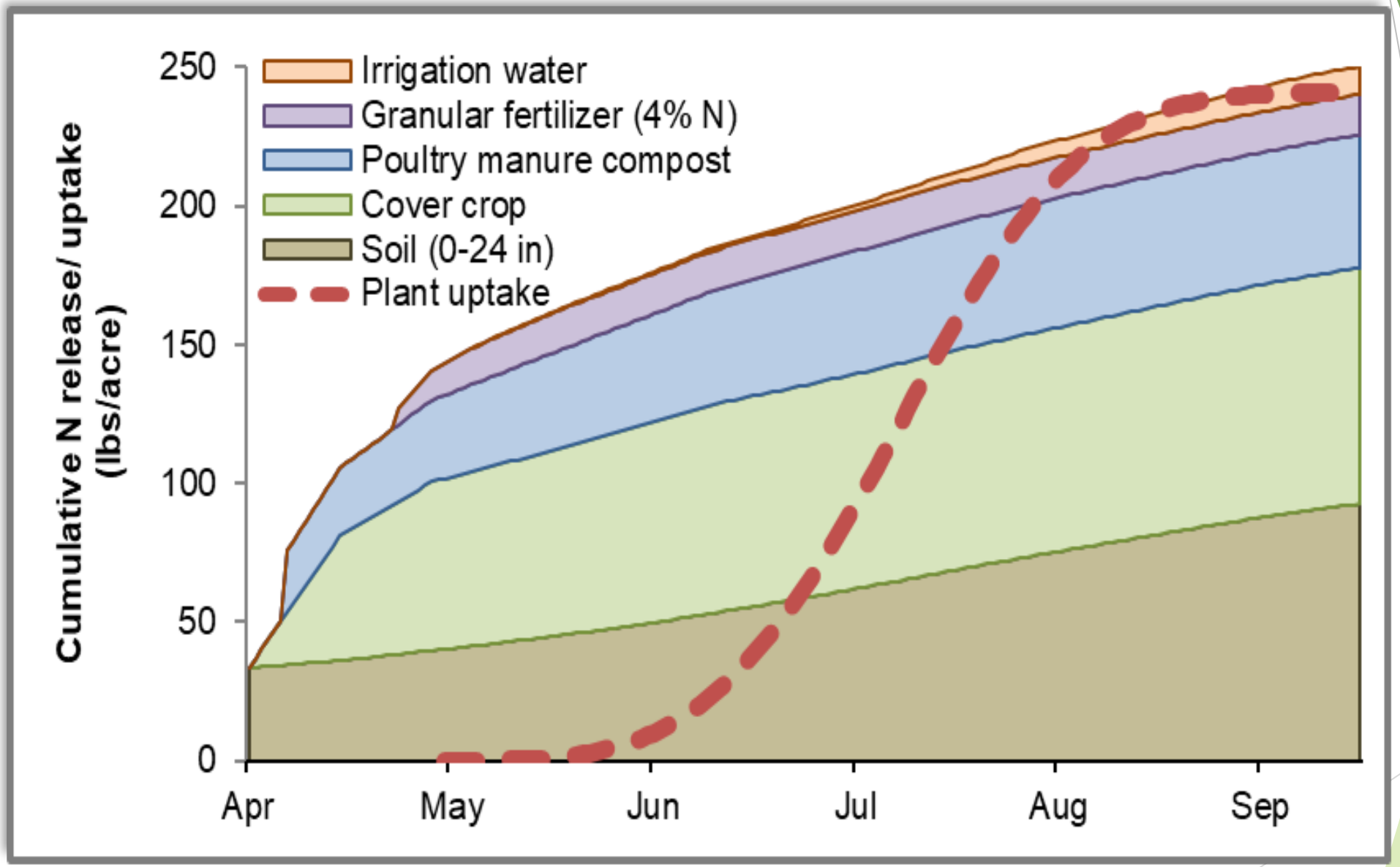
DO NOT USE DRYERS FOR
STORAGE. REMOVE MATERIAL
WHEN DRY. IF MATERIALS ARE
NOT REMOVED WHEN DRY,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